Shaking
Shaking is a more vigorous form of vibration applied during exhalation using an intermittent bouncing maneuver coupled with wide movements of the therapist's hands. The therapist's thumbs are locked together, the open hands are placed directly on the patient's skin, and fingers are wrapped around the chest wall. The therapist simultaneously compresses and shakes the chest wall.[25,51,72]

Postural Drainage Positions

Positions for postural drainage are based on the anatomy of the lungs and the tracheobronchial tree (see Figs. 25.2 and 25.4). Each segment of each lobe is drained using the positions depicted in Figures 25.26 through 25.37. The shaded area in each illustration indicates the area of the chest wall where percussion or vibration is applied.

RIGHT AND LEFT UPPER LOBES

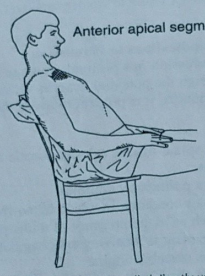

FIGURE 25.26 Percussion is applied directly under the clavicle.

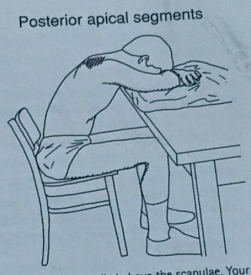

FIGURE 25.27 Percussion is applied above the scapulae. Your fingers curve over the top of the shoulders.

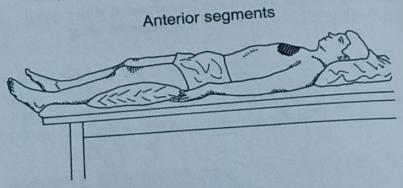

FIGURE 25.28 Percussion is applied bilaterally, directly over the nipple or just above the breast.

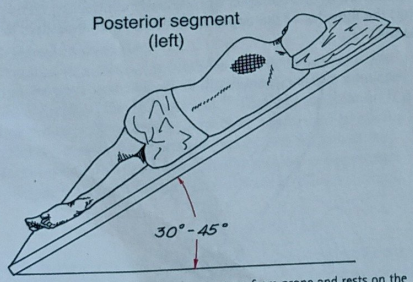

FIGURE 25.29 Patient lies one-quarter turn from prone and rests on the right side. Head and shoulders are elevated 45° or approximately 18 inches if pillows are used. Percussion is applied directly over the left scapula.

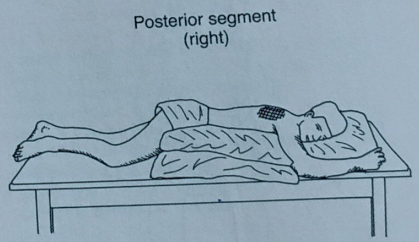

FIGURE 25.30 Patient lies flat and one-quarter turn from prone on the left side. Percussion is applied directly over the right scapula.

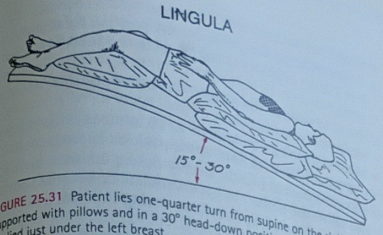

FIGURE 25.31 Patient lies one-quarter turn from supine on the right side, supported with pillows and in a 30° head-down position. Percussion is applied just under the left breast.

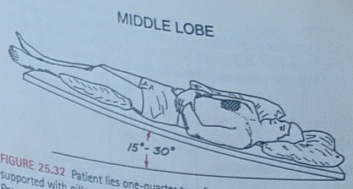

FIGURE 25.32 Patient lies one-quarter turn from supine on the left side, supported with pillows behind the back, and in a 30° head-down position. Percussion is applied under the right breast.

RIGHT AND LEFT LOWER LOBES

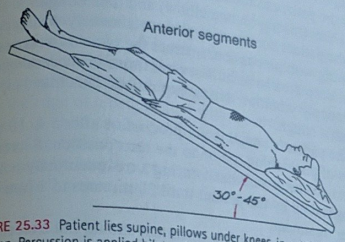

FIGURE 25.33 Patient lies supine, pillows under knees, in a 45° head-down position. Percussion is applied bilaterally over the lower portion of the ribs.

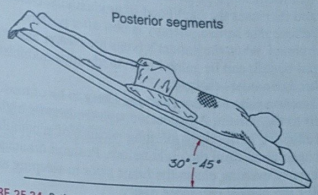

FIGURE 25.34 Patient lies prone with a pillow under the abdomen in a 45° head-down position. Percussion is applied bilaterally over the lower portion of the ribs.

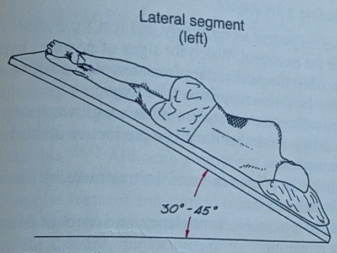

FIGURE 25.35 Patient lies on the right side in a 45° head-down position. Percussion is applied over the lower lateral aspect of the left rib cage.

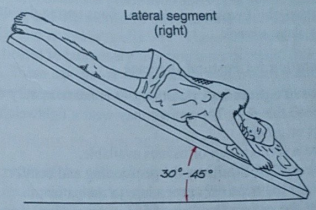

FIGURE 25.36 Patient lies on the left side in a 45° head-down position Percussion is applied over the lower lateral aspect of the right rib cage.

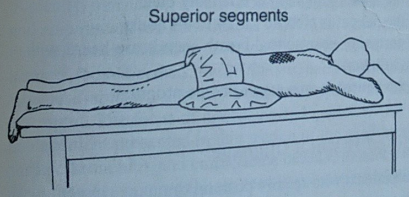

FIGURE 25.37 Patient lies prone with a pillow under the abdomen to flatten the back. Percussion is applied bilaterally, directly below the scapulae.

Extent of excursion. The extent of chest mobility can be measured by two methods.[35,38]

- Measure the girth of the chest with a tape measure at three levels (axilla, xiphoid, lower costal). Document change in girth after a maximum inspiration and a maximum expiration.
- Place both hands on the patient's chest or back as previously described. Note the distance between your thumbs after a maximum inspiration.

Palpation

Palpation of the thorax provides evidence of dysfunction of the underlying tissues including the lungs, chest wall, and mediastinum.[11,35,38,52]

Tactile (vocal) fremitus. Tactile fremitus is the vibration felt while palpating over the chest wall as a patient speaks.

Procedure: Place the palms of your hands lightly on the chest wall and ask the patient to speak a few words or repeat "99" several times. Normally, fremitus is felt uniformly on the chest wall. Fremitus is increased in the presence of secretions in the airways and decreased or absent when air is trapped as the result of obstructed airways.

Chest wall pain. Specific areas or points of pain over anterior, posterior, or lateral aspects of the chest wall can be identified with palpation.

Procedure: Firmly press against the chest wall with your hands to identify any specific areas of pain potentially of musculoskeletal origin. Ask the patient to take a deep breath and identify any painful areas of the chest wall. Chest wall pain of musculoskeletal origin often increases with direct point pressure during palpation and during a deep inspiration.[35,38]

NOTE: Pain in the anterior, posterior, or lateral region of the chest can be of musculoskeletal, pulmonary, or cardiac origin.[31] Pain of pulmonary origin is usually localized to a region of the chest but also may be felt in the neck or shoulder region. Several pulmonary or cardiac conditions

was proposed by a joint committee of the American College of Chest Physicians and the American Thoracic Society.[1,77] Adventitious breath sounds are categorized as *crackles* or *wheezes*. Box 25.5 describes the location and quality of these breath sounds.

BOX 25.5 Normal and Adventitious Breath Sounds

Normal Breath Sounds

- *Vesicular.* Soft, low-pitched, breezy but faint sounds heard over most of the chest except near the trachea and mainstem bronchi and between the scapulae. Vesicular sounds are audible considerably longer on inspiration than expiration (about a 3:1 ratio).
- *Bronchial.* Loud, hollow, or tubular high-pitched sounds heard over the mainstem bronchi and trachea. Bronchial sounds are heard equally during inspiration and expiration; a slight pause in the sound occurs between inspiration and expiration.
- *Bronchovesicular.* Softer than bronchial breath sounds; also heard equally during inspiration and expiration but without a pause in the sound between the cycles. The sounds are heard in the supraclavicular, suprascapular, and parasternal regions anteriorly and between the scapulae posteriorly.

Adventitious Breath Sounds

- *Crackles.* Fine, discontinuous sounds (similar to the sound of bubbles popping or the sound of hairs being rubbed between your fingers next to your ear). Crackl which can be fine or coarse, are heard primarily duri inspiration as the result of secretions moving in the a ways or in closed airways that are rapidly reopening former term for crackles was *rales*.
- *Wheezes.* Continuous high- or low-pitched sounds o sometimes musical tones heard during exhalation bu occasionally audible during inspiration. Bronchospa or secretions that narrow the lumen of the airways wheezes. The term previously used for wheezes was *rhonchi*.

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Adventitious Breath Sounds

- *Crackles.* Fine, discontinuous sounds (similar to the sound of bubbles popping or the sound of hairs being rubbed between your fingers next to your ear). Crackles, which can be fine or coarse, are heard primarily during inspiration as the result of secretions moving in the airways or in closed airways that are rapidly reopening. The former term for crackles was *rales.*
- *Wheezes.* Continuous high- or low-pitched sounds or sometimes musical tones heard during exhalation but occasionally audible during inspiration. Bronchospasm or secretions that narrow the lumen of the airways cause wheezes. The term previously used for wheezes was *rhonchi.*

chospasm and increased airway restriction.

- Do not allow a patient to take a highly *prolonged* expiration. This causes the patient to gasp with the next inspiration. The patient's breathing pattern then becomes irregular and inefficient.
- Do not allow the patient to initiate inspiration with the accessory muscles and the upper chest. Advise the patient that the upper chest should be relatively quiet during breathing.
- Allow the patient to perform deep breathing for only three or four inspirations and expirations at a time to avoid hyperventilation.

Diaphragmatic Breathing

When the diaphragm is functioning effectively in its role as the primary muscle of inspiration, ventilation is efficient and the oxygen consumption of the muscles of ventilation is low during relaxed (tidal) breathing.[7,28] When a patient relies substantially on the accessory muscles of inspiration, the mechanical work of breathing (oxygen consumption) increases and the efficiency of ventilation decreases. Although the diaphragm controls breathing at an involuntary level, a patient with primary or secondary pulmonary dysfunction can be taught how to control breathing by optimal use of the diaphragm and decreased use of accessory muscles.

Controlled breathing techniques, which emphasize diaphragmatic breathing, are designed to improve the efficiency of ventilation, decrease the work of breathing, increase the excursion (descent or ascent) of the diaphragm, and improve gas exchange and oxygenation.[11,28,44,48,60] Diaphragmatic breathing exercises also are used during postural drainage to mobilize lung secretions.[25,51]

Procedure

- Prepare the patient in a relaxed and comfortable position in which gravity *assists* the diaphragm, such as a semi-Fowler's position.
- If your examination revealed that the patient initiates the breathing pattern with the accessory muscles of inspiration (shoulder and neck musclulature), start instruction by teaching the patient how to relax those muscles (shoulder rolls or shoulder shrugs coupled with relaxation).
- Place your hand(s) on the rectus abdominis just below the anterior costal margin (Fig. 25.9). Ask the patient to breathe in slowly and deeply through the nose. Have the patient keep the shoulders relaxed and upper chest quiet, allowing the abdomen to rise slightly. Then tell the patient to relax and exhale slowly through the mouth.

FIGURE 25.9 The semireclining (as shown) and semi-Fowler's positions are comfortable, relaxed positions in which to teach diaphragmatic breathing.

- Have the patient practice this three or four times and then rest. Do not allow the patient to hyperventilate.
- If the patient is having difficulty using the diaphragm during inspiration, have the patient inhale several times in succession through the nose by using a *sniffing* action.[28,60] This action usually facilitates the diaphragm.
- To learn how to self-monitor this sequence, have the patient place his or her own hand below the anterior costal margin and feel the movement (Fig. 25.10). The patient's hand should rise slightly during inspiration and fall during expiration.

FIGURE 25.10 The patient places his or her own hands on the abdomen to feel the movement of proper diaphragmatic breathing. By placing the hands on the abdomen, the patient can also feel the contraction of the abdominals, which occurs with controlled expiration or coughing.

- After the patient understands and is able to control breathing using a diaphragmatic pattern, keeping the shoulders relaxed, practice diaphragmatic breathing in a variety of positions (sitting, standing) and during activity (walking, climbing stairs).

NOTE: Evidence concerning the effect of diaphragmatic breathing exercises on the rate of ventilation, the work of breathing and oxygen consumption, excursion of the diaphragm, and exercise capacity in normal subjects and in patients with pulmonary disorders is inconclusive, with some studies supporting and others refuting the benefits of diaphragmatic breathing.[13,28,44,62]

Segmental Breathing

It is questionable whether a patient can be taught to expand localized areas of the lungs while keeping other areas quiet. It is known, however, that hypoventilation does occur in certain areas of the lungs because of chest wall fibrosis, pain, and muscle guarding after surgery, atelectasis, and pneumonia. Therefore, there are certain instances such as during postural drainage or following thoracic surgery when it is important to emphasize expansion of problem areas of the lungs and chest wall.

Two examples of segmental breathing that target the lateral and posterior segments of the lower lobes are described in this section. However, segmental breathing techniques also may need to be directed to the middle and upper lobes if there is accumulation of secretions or insufficient lung expansion in these areas.

Lateral Costal Expansion

Lateral costal expansion, sometimes called *lateral basal expansion*, can be carried out unilaterally or bilaterally.

Deep breathing while focusing on movement of the lower portion of the rib cage may facilitate diaphragmatic excursion.[28] This technique is particularly important for the patient with a stiff lower rib cage, as is often seen with chronic bronchitis, emphysema, or asthma.[7]

Procedure

- Have the patient begin in a hook-lying position; later progress to a sitting position. Place your hands along the lateral aspect of the lower ribs to direct the patient's attention to the areas where movement is to occur (Figs. 25.11 and 25.12).

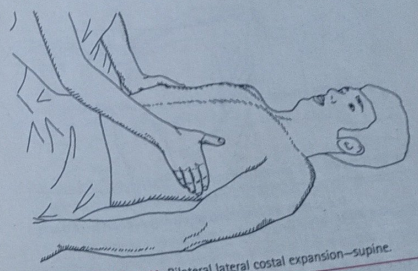

FIGURE 25.11 Bilateral lateral costal expansion—supine.

FIGURE 25.12 Bilateral lateral costal expansion—sitting.

- Ask the patient to breathe out, and feel the rib cag
downward and inward. As the patient breathes ou
pressure into the ribs with the palms of your han
- Just prior to inspiration, apply a quick downwar
and inward stretch to the chest. This places a q

stretch on the external intercostals to facilitate their contraction.

- Apply *light* manual resistance to the lower ribs to increase sensory awareness as the patient breathes in deeply and the chest expands and ribs flare. Then, as the patient breathes out, assist by gently squeezing the rib cage in a downward and inward direction.
- Teach the patient how to perform the maneuver independently by placing his or her hand(s) over the ribs (Fig. 25.13) or applying resistance with a towel or belt around the lower ribs (Fig. 25.14A&B).

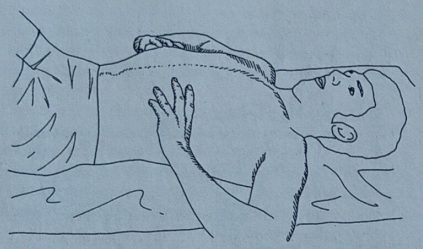

FIGURE 25.13 The patient applies his or her own manual pressure during lateral costal expansion.

Posterior Basal Expansion

Deep breathing emphasizing posterior basal expansion is important for the postsurgical patient who is confined to bed in a semireclining position for an extended period of time because secretions often accumulate in the posterior segments of the lower lobes.

Procedure

Have the patient sit and lean forward on a pillow, slightly bending the hips (see Fig. 25.15). Place your hands over the posterior aspect of the lower ribs, and follow the same procedure just described for lateral costal expansion.

Pursed-Lip Breathing

Pursed-lip breathing is a strategy that involves lightly pursing the lips together during controlled exhalation. This breathing pattern often is adopted spontaneously by patients with COPD to deal with episodes of dyspnea.[7,10,28,43,48] Patients with COPD using pursed-lip breathing report a decrease in their perceived level of exertion during activity.[10]

However, whether it is beneficial to teach a patient pursed-lip breathing often is debated. Many therapists believe that gentle pursed-lip breathing and controlled expiration is a useful procedure, particularly to relieve dyspnea if it is performed appropriately. It is thought to keep airways open by creating back-pressure in the airways. Studies suggest that pursed-lip breathing decreases the respiratory rate and the work of breathing (oxygen consumption), increases the tidal volume, and improves exercise tolerance.[15,28,43,48]

PRECAUTION: The use of *forceful* expiration during pursed-lip breathing must be avoided. Forceful expiration while the lips are pursed can increase the turbulence in the airways and cause further restriction of the small bronchioles. Therefore, if a therapist elects to teach this breathing strategy, it is important to emphasize with the patient that expiration should be performed in a controlled manner but not forced.

Procedure

Have the patient assume a comfortable position and relax as much as possible. Have the patient breathe in slowly and deeply through the nose and then breathe out gently through lightly pursed lips as if blowing on and bending the flame of a candle but not blowing it out.[43] Explain to

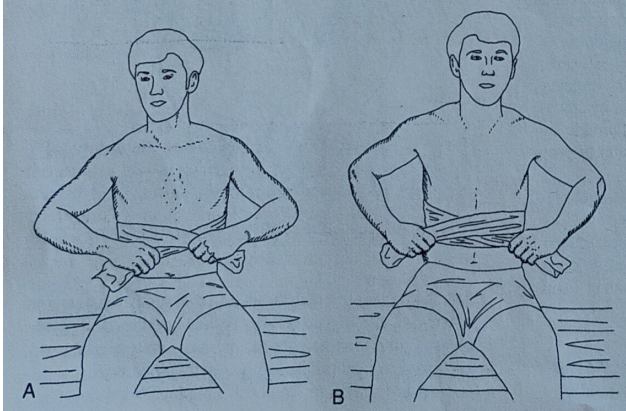

FIGURE 25.14 Belt exercises reinforce lateral costal breathing (*A*) by applying resistance during inspiration and (*B*) by assisting with pressure along the rib cage during expiration.

the patient that expiration must be relaxed and that contraction of the abdominals must be avoided. Place your hand over the patient's abdominal muscles to detect any contraction of the abdominals.

Preventing and Relieving Episodes of Dyspnea

Many patients with COPD (e.g., emphysema and asthma) may suffer from periodic episodes of dyspnea (shortness of breath), particularly with physical exertion or when in contact with allergens. Whenever a patient's normal breathing pattern is interrupted, shortness of breath can occur. It is helpful to teach a patient how to monitor his or her level of shortness of breath and to *prevent* episodes of dyspnea by *controlled breathing techniques, pacing activities,* and becoming aware of what activity or situation precipitates a shortness of breath attack.

Pacing is the performance of functional activities, such as walking, stair climbing, or work-related tasks, within the limits of a patient's ventilatory capacity.[11] Although some patients may understand intuitively the limits to which functional activities can be pushed, others must be taught to recognize the early signs of dyspnea. If the patient becomes slightly short of breath, he or she must learn to stop an activity and use controlled, pursed-lip breathing until the dyspnea subsides.

Procedure

- Have the patient assume a relaxed, forward-bent posture (Figs. 25.15 and 25.16; also see Fig. 25.6). A forward-bent position stimulates diaphragmatic breathing (the viscera drop forward and the diaphragm descends more easily). Use bronchodilators as prescribed.
- Have the patient gain control of his or her breathing and reduce the respiratory rate by using pursed-lip breathing during expiration. Have the patient focus on the expiratory phase of breathing while being sure to avoid forceful expiration.

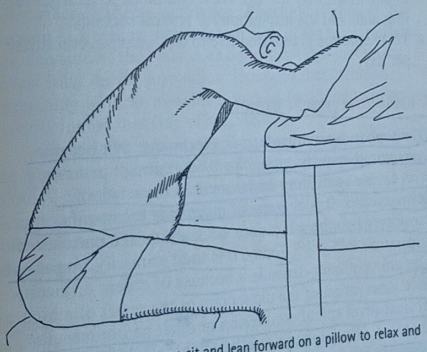

FIGURE 25.15 A patient can sit and lean forward on a pillow to relax and relieve an episode of dyspnea.

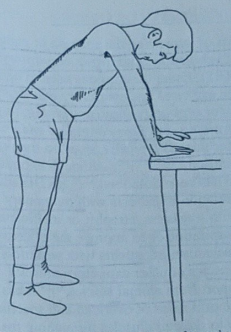

FIGURE 25.16 While standing, a patient can lean forward and place some weight on the hands to relieve dyspnea.

- After each pursed-lip expiration, teach the patient to use diaphragmatic breathing and minimize use of accessory muscles during each inspiration.
- Have the patient remain in a forward-bent posture and continue to breathe in a slow, controlled manner until the episode of dyspnea subsides.

Positive Expiratory Pressure Breathing

Positive expiratory pressure breathing is a technique in which resistance to airflow is applied during exhalation, similar to what occurs during pursed-lip breathing, except that the patient breathes through a specially designed mouthpiece or mask that controls resistance to airflow.[19,20,25] This breathing technique is used to hold airways open during exhalation to mobilize accumulated secretions and improve their clearance. Positive expiratory pressure breathing provides an alternative or adjunct to postural drainage which a patient can perform independently.

Procedure

Positive expiratory pressure breathing is performed in an upright position, preferably seated with the elbows resting on a table. The procedure can be performed against low or high pressure. A low pressure technique involves tidal inspiration and active, but not forced, expiration through a mouthpiece or mask. The patient inhales, holds the inspiration for 2 to 3 seconds, and then exhales, repeating the sequence for approximately 10 to 15 cycles.[19,20,25] The patient removes the mouthpiece or mask, takes several "huffs" and then coughs to clear the mobilized secretions from the airways. The breathing sequence typically is repeated four to six times with a total treatment session lasting about 15 minutes.

Respiratory Resistance Training

The process of improving the strength or endurance of the muscles of ventilation is known as *respiratory resistance training* (RRT). Other descriptions used to denote this form of breathing exercises are *ventilatory muscle training, inspiratory* (or *expiratory*) *muscle training, inspiratory resistance training,* and *flow-controlled endurance training.* These techniques typically focus on training the muscles of inspiration,[14,26,32,33,34,65] although expiratory muscle training also has been described.[32,33] RRT is advocated to improve ventilation in patients with pulmonary dysfunction associated with weakness, atrophy, or inefficiency of the muscles of inspiration or to improve the effectiveness of the cough mechanism in patients with weakness of the abdominal muscles or other expiratory muscles.

With support from animal studies,[46,62] it has been suggested that the principles of overload and specificity of training apply to skeletal muscles throughout the body, including the muscles of ventilation.* In humans, it is not feasible to use invasive procedures to evaluate morphological or histochemical changes in the diaphragm that may occur as the result of strength or endurance training. Instead, strength or endurance changes must be assessed indirectly. Increases in respiratory muscle strength and endurance are determined by ultrasonographic meaurements of the thickness of the diaphragm, maximal voluntary ventilation, and decreased reliance on accessory muscles of inspiration. Respiratory muscle strength (either inspiratory or expiratory) also is evaluated indirectly with measurements of inspiratory capacity, forced expiratory volume, inspiratory mouth pressure using a spirometer, vital capacity, and increased cough effectiveness.

PRECAUTION: Avoid prolonged periods of any form of resistance training for inspiratory muscles. Unlike muscles of the extremities, the diaphragm cannot totally rest to recover from a session of resistance exercises. Use of accessory muscles of inspiration (neck and shoulder muscles) is a sign that the diaphragm is beginning to fatigue.[3,76]

Inspiratory Resistance Training

Inspiratory resistance training, using pressure- or flow-based devices to provide resistance to airflow, is designed to improve the strength and endurance of the muscles of inspiration and decrease the occurrence of inspiratory muscle fatigue. This technique has been studied in patients with acute and chronic, primary and secondary pulmonary disorders, including COPD,[1,15,54,64] cystic fibrosis,[26] respiratory failure and ventilator dependence (weaning failure),[2,65] chronic heart failure,[14] and chronic neuromuscular disease.[32] Although reviews of the literature have demonstrated that outcomes of inspiratory muscle training programs in patients with pathologies are inconsistent,[33,50] some positive changes reported after training are increased vital capacity, increased exercise capacity, and fewer episodes of dyspnea.[14,26,54] Inspiratory muscle training also has been studied and found to be effective (as evidenced by a decreased respiratory rate) in patients with cervical-level spinal cord lesions.[24,49,57,74]

Procedure

- The patient inhales through a resistive training device placed in the mouth. These devices are narrow tubes of varying diameters or a mouthpiece and adapter with an adjustable aperture that provide resistance to airflow during inspiration and therefore place resistance on inspiratory muscles. The smaller the diameter of the aperture and the faster the rate of airflow, the greater is the resistance.
- The patient inhales through the device for a specified period of time several times each day. The time is gradually increased to 20 to 30 minutes at each training session to increase inspiratory muscle endurance.

Incentive Respiratory Spirometry

Incentive spirometry is a form of ventilatory training that emphasizes sustained maximum inspirations.[18,48,60] The patient inhales as deeply as possible through a small, hand-held spirometer that provides visual or auditory feedback about whether a target maximum inspiration was reached. Typically, this breathing technique is performed while using a spirometer, but it also may be performed without the equipment.

The purpose of incentive spirometry is to increase the volume of air inspired. It is used primarily to prevent alveolar collapse and atelectasis in postoperative patients. Despite the widespread use of incentive spirometry for patients after surgery, the effectiveness of this technique alone or in addition to general deep breathing and coughing for the prevention of postoperative pulmonary complications is not clear.[18,40,71]

Procedure

- Have the patient assume a comfortable position (semireclining, if possible) and inhale and exhale three to four times and then exhale maximally with the fourth breath.
- Then have the patient place the spirometer in the mouth, inhale maximally through the mouthpiece to a target setting and hold the inspiration for several seconds.
- This sequence is repeated five to ten times several times per day.

Glossopharyngeal Breathing

Glossopharyngeal breathing is a technique that became known to therapists during the 1950s through patients with severe ventilatory impairment as the result of poliomyelitis. It is a means of increasing the inspiratory capacity when there is severe weakness of the muscles of inspiration.[28,39,53,75,76] Today, it is used primarily by patients who are ventilator-dependent because of absent or incomplete innervation of the diaphragm as the result of a high cervical-level spinal cord lesion or other neuromuscular disorders. Glossopharyngeal breathing combined with the inspiratory action of the neck musculature can reduce ventilator dependence or can be used as an emergency procedure should a malfunction of a patient's ventilator

* See references 1–3, 15, 26, 32, 33, 44, 46, 54, 57, 62, 65, 71, 76.

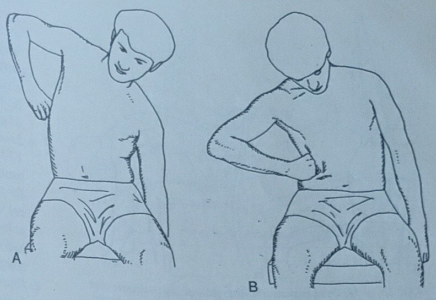

FIGURE 25.17 Chest mobilization during inspiration and expiration. To mobilize the lateral rib cage have the patient (*A*) bend away from the tight side during inspiration and (*B*) bend toward the tight side during expiration.

occur.[3,39,53,75,76] It also can be used to improve the force (and therefore the effectiveness) of a cough or increase the volume of the voice.

Procedure

Glossopharyngeal breathing involves taking several "gulps" of air, usually 6 to 10 gulps in series, to pull air into the lungs when action of the inspiratory muscles is inadequate. After the patient takes several gulps of air, the mouth is closed, and the tongue pushes the air back and traps it in the pharynx. The air is then forced into the lungs when the glottis is opened. This increases the depth of the inspiration and the patient's inspiratory and vital capacities.[39,75]

Exercises to Mobilize the Chest

Chest mobilization exercises are any exercises that combine active movements of the trunk or extremities with deep breathing.[21,60] They are designed to maintain or improve mobility of the chest wall, trunk, and shoulder girdles when it affects ventilation or postural alignment. For example, a patient with hypomobility of the trunk muscles on one side of the body does not expand that part of the chest fully during inspiration. Exercises that combine stretching of these muscles with deep breathing improve ventilation on that side of the chest.

Chest mobilization exercises also are used to reinforce or emphasize the depth of inspiration or controlled expiration. A patient can reinforce expiration, for example, by leaning forward at the hips or flexing the spine as he or she breathes out. This pushes the viscera superiorly into the diaphragm.

Specific Techniques

To Mobilize One Side of the Chest

- While sitting, have the patient bend away from the tight side to lengthen hypomobile structures and expand that side of the chest during inspiration (Fig. 25.17A).
- Then, have the patient push the fisted hand into the lateral aspect of the chest, bend toward the tight side, and breathe out (Fig. 25.17B).
- Progress by having the patient raise the arm overhead on the tight side of the chest and side-bend away from the tight side. This places an additional stretch on hypomobile tissues.

To Mobilize the Upper Chest and Stretch the Pectoralis Muscles

- While the patient is sitting in a chair with hands clasped behind the head, have him or her horizontally abduct the arms (elongating the pectoralis major) during a deep inspiration (Fig. 25.18A).
- Then instruct the patient to bring the elbows together and bend forward during expiration (Fig. 25.18B).

To Mobilize the Upper Chest and Shoulders

While sitting in a chair, have the patient reach with both arms overhead (180° bilateral shoulder flexion and slight abduction) during inspiration (Fig. 25.19A) and then bend forward at the hips and reach for the floor during expiration (Fig. 25.19B).

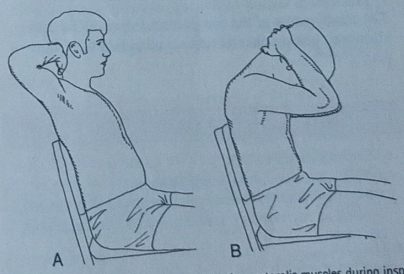

FIGURE 25.18 (*A*) A stretch is applied to the pectoralis muscles during inspiration, and (*B*) the patient brings the elbows together to facilitate expiration.